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William Donald Schaefer
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Secretary

November 4, 1994

Mr. Jerry Hoover
Remedial Project Manager
U.S. Environmental Protection Agency
Region III
841 Chestnut Building
Philadelphia, PA 19107

Dear Mr. Hoover:

Enclosed are revisions and additions to the Maryland Department of the Environment, Waste Management Administration's comments (dated September 30, 1994) from technical review of the report entitled "Draft Focused Remedial Investigation Report of the Galaxy/Spectron Site", dated May 4, 1994.

These revisions and additions are the result of a technical meeting held at the U.S. Environmental Protection Agency's Region III Offices on October 13, 1994.

Revisions to the original text were made in the last paragraph of comment #15. Additions to the text include:

1) Comment #45.
2) Three additional Figures (MDE Figures #3, #4 and #5).
3) General Comments #2 and #3.

If we can assist you further in this matter, please call either myself or David Healy at (410) 631-3440.

Sincerely,

Rick Grills

Rick Grills
Remedial Project Manager
Federal/NPL Superfund Division

RG/cb
Enclosure
cc: Mr. Richard Collins
Mr. Robert DeMarco

MARYLAND DEPARTMENT OF THE ENVIRONMENT
WASTE MANAGEMENT ADMINISTRATION
Comments on the Draft Focused Remedial Investigation
Report, Galaxy/Spectron Site
Cecil County, Maryland

General Comments:

1) There are still discrepancies in the spatial relationships of building locations, relative to soil boring locations, geoprobe data points, seismic line locations, bedrock topography and seismic velocity anomalies, etc. For example, the location of seismic line SL-3 (Figure 1-4) was revised approximately 25 feet from its location in the 10/15/93 Step Two Data Package (Figures 1 and 2). There was, however, no commensurate shift of the color-coded anomalies on Figures 2-2 and 2-4. Because there are very steep gradients in both seismic velocity and bedrock elevation (topography) in this particular area, the color-coded data on these maps no longer represents the actual data from seismic line SL-3. Other problems with spatial relationships between cultural and site specific investigation points include:

   A. The distance separating SL-3 and SL-12, SL-4 and SL-13, etc.

   B. The locations of SL-13, SL-14, and SL-15 partially to completely in the creek-bed. These lines were not shot in the creekbed.

   C. The incorrect dimensions of the L-shaped building between SL-1 and SL-3 (see Figure 1-4). This affects the location of MW-9 relative to the creek and the building (see Figure 1-2).

   This discrepancy probably has shifted the location of geoprobe borings G-35 through G-38 further away from the edge of the creek than their true ground location at the site.

   Before the remedial actions begin, an accurate site base map must be constructed. Only then can the correct spatial relationships between investigation-derived data point locations and the cultural features at the site be accurately portrayed.

2) Because of the demonstrated complexity of evaluating the geophysical parameters of the bedrock aquifer, it is strongly suggested that an outside firm which specializes in seismic methods of characterizing fractured bedrock aquifers should be retained for this purpose. This firm should review the geophysical work performed up to this time and make recommendations on further work required to characterize the bedrock aquifer for removal actions which may be deemed appropriate in the near future.

   The ultimate effectiveness of any integrated geophysical investigation depends upon choosing the appropriate geophysical methods to characterize the physical parameters of concern. The calibration and accuracy of these geophysical methods must be determined by comparison with known subsurface parameters measured at locations coinciding with the exact locations where the geophysical surveys were performed. Tying geophysical measurements with known subsurface data is critical to the processing, interpretation, and ultimate usefulness of that geophysical data in an integrated subsurface investigation.

The distribution of contaminant concentrations in the bedrock aquifer (as exemplified by AW-1 and AW-2) appear to coincide with petrophysical properties of the aquifer (degree of weathering, fracture density, fracture interconnection, porosity, etc. - See Maryland Department of the Environment [MDE] Figure 3.) These petrophysical properties can be qualitatively measured as discrete zones of varying thickness by the appropriate geophysical methods which respond to these properties (borehole geophysics and various seismic borehole imaging techniques). The petrophysical properties observed in the borehole can be extrapolated three-dimensionally away from the borehole by such techniques as vertical seismic profiling, cross-hole and surface to borehole seismic tomography, cross-hole packer testing, azimuthal electrical resistivity surveys, etc. Once the three-dimensional aspects of bedrock petrophysical properties have been established in the specific test area (e.g. in the vicinity of AW-1 and AW-2), the petrophysical properties of interest can be extrapolated as subsurface trends with appropriate geophysical surveys.

Because of the demonstrated coincidence of contaminant distribution in the bedrock aquifer with geophysically-defined aquifer characteristics, the usefulness of appropriately chosen and thoughtfully interpreted geophysical surveys has been proven.

3) The strong coincidence of stratification of contaminant concentrations and apparent fracture intensity zones within the bedrock aquifer has significant implications on contaminant migration within the bedrock (MDE Figure 4). The much higher total VOC concentrations in the "slightly fractured" zones of both AW-1 and AW-2 suggests that some of the fractures contain mobile Dense Non-Aqueous Phase Liquid (DNAPL) compounds. Because of increased overburden confining pressure with depth, fracture apertures and fracture intensity generally decrease with depth. The significant reduction in total VOC concentrations below 100 feet in AW-1 suggests that further downward migration of potential mobile DNAPL compounds is not likely. The zone from approximately 60 feet to 100 feet in AW-1 and below 87 feet in AW-2 apparently represents a perched DNAPL reservoir system in pseudo-equilibrium with respect to further downward migration.

Because of significant differences in the thickness of the "highly fractured" and "moderately fractured" zones in AW-1 and AW-2, there is a high potential for lateral migration of mobile DNAPL compounds form the "slightly fractured" zone in AW-1 to the "moderately fractured" zone in AW-2. Actual DNAPL migration will be a function of fracture interconnection, fracture aperture and degree of secondary porosity development due to weathering.

Assuming there is some downgradient (gravitational) flow of DNAPL from the slightly fractured to the moderately fractured strata, the direction of that flow would be determined by the orientation of the fracture zone causing the enhanced bedrock fracturing. In order to evaluate whether this lateral downgradient migration is occurring, it is necessary to evaluate if these fracture zones exist; and, if so, do they provide a contiguous permeability pathway to allow off-site migration of the DNAPL? If contiguous off-site fracture zones are not present, do these localized fracture zones provide gravitational "sinks" for DNAPL compounds migrating downward through the bedrock fracture system? These are questions which must be addressed.

A generalized conceptual model of the subsurface stratigraphy and bedrock fracture zones is presented in MDE Figure 5. This model was constructed to honor all site specific subsurface data which has been gathered to date, and to provide a possible model for contaminant distribution and lateral migration in the bedrock aquifer.

Specific Comments:

Figure 1-4

1) There are serious discrepancies in the location and/or length of seismic lines in this figure compared to the same seismic lines in Figures 1 and 2 of the 10/15/93 Step Two Data Package Report. Please explain and reconcile these discrepancies.

2) It would be useful to have an expanded scale base map with the shot points, geophone locations, and line tie points marked for each seismic line. This will only be possible, however, after an accurate base map for the site is constructed.

3) The L-shaped building between monitoring wells 8 and 9 is shown on site diagrams to have dimensions that are different from those of the on-site building dimensions. On-site measurements will be required to quantify the exact discrepancy.

Section 2.2 - Bedrock Surface Topography

4) Please include as an appendix the procedures and calculations for one of the site specific seismic refraction lines. This appendix should illustrate all data acquisition, processing, data reduction techniques, assumptions, etc. used to derive the following values used in this report:

   A. Depth to bedrock.
   B. Velocity of overburden.
   C. Velocity of bedrock at the acoustic interface between bedrock and overburden.

D. Special Case of depth to bedrock below the stream bed.

Figure 2-2 - Bedrock Surface Topographic Map

5) The color-coded elevations surrounding soil boring location B-3 show it as a small localized depression. This is statistically untenable and is not supported by soil borings B-1 and B-3. In addition, the bedrock seismic velocity map in this portion of the site indicates a probable lower velocity zone (fracture zone?) trending in a north-south direction.

6) Please include a table which lists the ground elevations (surveyed or estimated) of the B-series soil borings. This is required to assess the actual elevations of the auger refusal depths of the soil borings which are given as depth below ground surface.

7) Figure 2-2 is based primarily on seismic refraction data. The locations of all the seismic lines should be accurately marked on this diagram. Please change the title of Figure 2-2 to reflect its primary data source - the seismic refraction surveys. Subsurface data seems to have been largely ignored.

Figure 2-3 - Bedrock Surface Cross Section

8) This figure is somewhat misleading in that it implies that there is a direct correlation between the stream bed of Little Elk Creek and the pronounced bedrock elevation change which forms a trough in the bedrock surface. This is not the case however. The two piezometers closest to this cross section (PZ-3 and PZ-8) are listed in Table 2-2 as bottoming in bedrock (refusal depth) at 195.73 and 195.67 feet respectively. Soil boring B-5, also located along this cross section, has an auger refusal depth of 15 feet below ground surface. Although ground surface elevations could not be found in this or previous reports for the B-series soil borings, it is estimated to be approximately 210 feet based on topographic maps in previous reports. The actual elevation of auger refusal in soil boring B-5, then, is 195 feet. Thus the elevation of the top of bedrock (auger refusal depth) in soil boring B-5 is essentially the same as it is in the two creek piezometers.

9) We recommend that Figure 2-3 be revised to include:

A. The locations and bedrock elevations (refusal depths) of soil borings B-4 and B-5, and piezometers PZ-3 and PZ-8. These can be projected into the line of cross section.

B. Define the actual limits of the incised creek channel on the diagram by including a separate topographic profile above the bedrock surface profile.

c. Include a horizontal as well as vertical scale and make sure all data points and stream features are spatially accurate on the cross section.

Section 2.2, page 29, third paragraph

10) There is no substantiation in the data collected to date for the unweathered bedrock topographic ridge. The average elevation of refusal depths for the 23 creekbed piezometers in Table 2-2 is 195.92 feet. The three piezometers located on the proposed ridge (PZ-18, PZ-14, and PZ-9) have an average refusal depth elevation of 196.24 feet. It is apparent that this is a difference of only 0.32 feet and does not constitute a significant bedrock elevation difference in the vicinity of the proposed unweathered ridge.

In terms of seismic bedrock velocity (degree of weathering), seismic lines #4 and #13 indicate relatively unweathered bedrock velocities of 15,000 - 17,000 feet/second in the vicinity of the proposed ridge. Seismic line #13, however, indicates that the depth to bedrock in soil boring B-7 is only 4-5 feet below the surface. The refusal depth in B-7 was 12.5 feet. Also on line #13, soil boring B-8 had an auger refusal depth of 14 feet instead of the 5-7 feet depth indicated by the refraction seismic data. Soil boring B-5 is located very close to seismic line #10 which traverses the creek. Auger refusal in B-5 was 15 feet below the surface but the seismic data indicated a depth to bedrock of only 8-9 feet at that point. These rather significant discrepancies between auger refusal depths and seismically computed depths to the acoustic bedrock horizon should not be ignored.

The coincidence of many of these seismically-calculated acoustic bedrock interfaces with known water level depths in the soil borings introduces the possibility of refractions from the saturated zone being mistaken for bedrock refractions. Please address this possibility. In addition there is a considerable discrepancy of where these seismic lines are located on the report map versus where the lines are located on the ground at the site. An accurate shot point base is required to remedy this situation.

Seismic lines #10 and #11 both traverse the creek on either side of the proposed unweathered ridge. Both of these lines illustrate the abrupt and very steep bedrock velocity gradients as these lines traverse from the relatively unweathered bedrock terrain beneath the site to the weathered and fractured bedrock terrain in the vicinity of the creekbed. There is no reason to suggest that the same type of abrupt transition from unweathered to weathered bedrock does not exist in the area characterized as "the unweathered bedrock ridge". This transition from unweathered to weathered bedrock would have to occur at some point northeast of seismic line #13. Please re-evaluate your position in support of an unweathered bedrock ridge as shown on Figure 2-4.

Figures 2-8 and 2-9

11) Please correct the spelling of the word "mineralogy" in the Legend.

12) Because all of the subsurface data on these figures is referenced to drilling depth rather than vertical depth, these figures should have the drilling depth scale on the left side of the diagram (next to the well construction log) rather than on the right side.

13) The gamma-ray curve used appears to be an unsmoothed field print. The maximum vertical bed resolution of the natural gamma tool is 2-3 feet so the spikes do not actually represent real lithologic variations in the bedrock. The spikes represent the statistical sampling frequency of the tool and should be smoothed to more closely represent real lithologic variations in the rock penetrated. Please check with your borehole geophysical contractor to obtain a final smoothed gamma-ray curve for these diagrams.

Page 35, Fracture Frequency

14) The borehole geophysical curves (Figures 2-8 and 2-9) suggest the following zones of fracture intensity within wells AW-1 and AW-2:

AW-1 (drilling depth):
Highly Fractured - 0 to 49 feet
Moderately Fractured - 49 to 60 feet
Slightly Fractured - 60 to 140 feet

AW-2 (drilling depth):
Highly Fractured - 0 to 64 feet
Moderately Fractured - 64 to 86 feet
Slightly Fractured - 86 to 140 feet

Differentiation into these zones is based upon borehole diameter, rugosity of the borehole wall, and the size and frequency of borehole washout areas (large fractures) as indicated on the caliper and normal resistivity logs (Figures 2-8 and 2-9). We do not believe it is appropriate to base fracture density solely on the basis of visible breaks in the cores. The effective fracture frequency is more accurately measured from the in-place aquifer parameters rather than visual inspection of cores exclusively. Many breaks within these cores are caused by stress during the coring process and are not present in the subsurface. Other criteria for conductive fractures should be present to distinguish physical breaks caused by the coring process from actual conductive fractures which are present in the subsurface. The borehole geophysical log response is the most accurate data source available to quantify these fractures and distinguish them from fractures induced solely by the core drilling process.

Section 3.2.1 - Hydraulic Conductivity

15. The conclusion is stated in the last paragraph that essentially all of the VOC mass contributed from the overburden flow system to the Creek comes exclusively from the central portion of the site. We cannot agree with this conclusion. A discussion of the basis for this disagreement is included in the following paragraphs.

The basis for the highly conductive nature of the aquifer in the vicinity of MW-10 appears to be the thick sand and gravel zone (see Figure 2-1) just above the overburden/bedrock interface. This sand and gravel zone is thickest in the central portion of the site adjacent to the present creekbed. This coarse-grained, highly conductive strata is also present, though considerably thinner, along the entire length of the site in areas adjacent to the present stream channel of Little Elk Creek. The sands, gravels, and silt bed appear to be alluvial floodplain deposits. The cumulative thickness of these alluvial deposits is related to underlying bedrock topography which, in turn, is believed to be related to fracture zones within the crystalline bedrock as well as erosional downcutting within the floodplain of the creek.

Figure 2-1 illustrates the occurrence and relative thickness of the sand/gravel zone from monitoring well and soil boring logs. The sand/gravel zone thickens between soil boring B-2 and well MW-9. Seismic lines have defined the abrupt transition from the sparsely-fractured, topographically positive bedrock terrain to the topographically negative, more highly-fractured areas where these floodplain deposits are concentrated. The sand/gravel zone is expected to continue abruptly thickening northeast of boring B-2 in the direction of the Creek. It appears that boring B-2 is very near the edge of the floodplain deposits of Little Elk Creek, where both the sand/gravel zone and the silt bed disappear (pinchout) against the topographically positive bedrock terrain. If, as expected, the sand/gravel floodplain deposits thicken significantly between boring B-2 and the creek bed, then significant discharge of contaminated groundwater into the Creek can be expected to occur in this part of the site as well as in the central portion of the site.

The curvature and orientation of the stream bed in the vicinity of the concrete dam, as well as the proximity of boring B-2 to the stream, suggests that the stream channel has meandered very close to the southwest limits of its incised floodplain. As the stream channel reverses direction past the concrete dam (Figure 2-1, Location Map Insert), the stream channel flows away from the southwestern edge of the floodplain deposits. As a result, more of the floodplain deposits have been preserved in the central and south part of the site between the present creek-bed location and the edge of the floodplain deposits beneath the site. This explains the greater thickness and aerial extent of these deposits as seen in wells, borings, and seismic lines located in the central and south portions of the site.

In summary, available data indicates that the highly conductive sand/gravel zone which discharges contaminated groundwater from the site to Little Elk Creek is present throughout the site downgradient of the pinchout of these deposits against the topographically positive bedrock terrain. This sand/gravel zone is expected to be somewhat thinner in the area between boring B-2 and the concrete dam. In this portion of the site, the active creek channel has eroded most of the conductive sand/gravel deposit.

Section 3.2.2 - Hydraulic Conductivity

16) There is some confusion in defining the variable "H" in the Hvorsley (1951) equation for calculating hydraulic conductivity from the packer test data. The variable term "H" is defined in the text as the "effective injection pressure head (ft.)". The term "effective" seems to imply that the aquifer hydrostatic pressure (hydraulic head) must be subtracted from the actual injection pressure to obtain the value of "H" in the equation. If, in fact, injection pressures did not exceed the hydraulic head of the packer tested interval, a negative injection (inflow into the packed-off wellbore zone) would occur. In Appendix H, however, the solutions for the Hvorsley (1951) hydraulic conductivity equation use the total pump pressure delivered to the test zone for the "H" variable. We are at a disadvantage in not having copies of the technical articles referred to in your list of references.

Please reconcile the perceived inconsistencies in definition of your terms for the Hvorsley (1951) equation and the exact definition of the "H" term in this equation.

Appendix H - Packer Test Calculations

17) The solutions to the Hvorsley (1951) equation shown in Section 3.2.2 appear to be incorrectly solved. The "H" variable has been corrected for hole deviation instead of the "L" variable (length of the test zone).

The "L" variable should be corrected for hole deviation in both the numerator and denominator of this equation.

Appendix H - Cross-Hole Testing Results

18) Please label the Time vs. Head diagrams in a more user friendly way. For example:

AW-1 (Zone 1) - Observation
AW-2 (Zone 1 and 2) - Injection

19) On all of the Time vs. Head diagrams, please show the initial hydraulic head of the observation zone prior to its response

to injection in the cross-hole tests. The second and third diagrams in the "Cross-Hole Testing Results" portion of Appendix H illustrate this type of preferred curve display.

Section 3.2.2 - Hydraulic Conductivity

20) Page 41, second paragraph, first sentence. Please change "AW-2, zone 5" to "AW-1, zone 5".

21) Refer to the packer test charts for AW-2, interval #1 and AW-2, interval #2 (Appendix H). In the interval #1 test (26.4' to 46.7'), the lower packer (zone 3) was apparently leaking. In the interval #2 test (47.4' to 67.7') the upper packer (zone 1) was apparently leaking. The two leaking packer zones are adjacent to one another. The two leaking packer seats are situated in a highly fractured, weathered part of the AW-2 wellbore, as indicated by the borehole diameter and rugosity of the borehole wall (see the caliper log, Figure 2-9). The roughness of the fractured, weathered borehole walls could have prevented the packers from maintaining a pressurized seal within the packed off interval. This situation is a common cause of packer failure in highly fractured bedrock. There is another possible explanation for these two failed packer tests, other than packer failure.

A second possible scenario to explain the two adjacent packer failure zones in the above tests is that the leakage occurred through fractures within the pressurized intervals and was communicated through interconnected fractures to the zone above or below the packers. This scenario would not necessitate a packer failure in either of these packer tests.

A possible solution to the question of which of the above scenarios actually occurred may be found in the cross-hole test graph in Appendix H for the AW-1, zone 1 response for packer tests in AW-2, zones 1 and 2. The monitored interval during these packer tests exhibited a pronounced head decline during the first 75 minutes of the monitoring period. This decline in aquifer head is more than three times greater than that encountered in any of the other cross-hole monitoring zones and suggests communication with the zone being packer tested during the earlier portion of the monitoring period. We do not know whether AW-2, zone 1 or AW-2, zone 2 was packer tested first during this cross-hole monitoring period. Please discuss the results of this cross-hole monitoring test and include in the report the sequence of packer tests recorded by this cross-hole monitoring test. Please indicate why you believe there was no cross-hole communication during these tests.

22) In the fourth paragraph of page 41, reference is made to the positive cross-hole response in AW-1, zone 1 during packer testing in AW-2, zones 3 and 4. There was no mention of the anomalous head response mentioned in MDE comment #21 from AW-1, zone 1 during packer testing in AW-2, zones 1 and 2. Possible responses during cross-hole monitoring in this zone occur at

40 to 60 minutes and at 75 to 130 minutes (see Appendix H, cross-hole testing results). These possible responses are superimposed on the rapidly declining head curve during the first half of the cross-hole monitoring period.

In MDE comment #14, it is suggested that the angled wells be divided into zones of varying fracture intensity, based primarily on borehole geophysical log response (highly fractured, moderately fractured and slightly fractured). It should be noted that cross-hole monitoring zone #1 of AW-1 encompasses all three of the proposed fracture intensity zones defined in MDE comment #14 (See enclosed MDE Figure #1). If these proposed zones do, in fact, represent zones of relative fracture intensity and interconnection, then it should not be surprising that a response in AW-1, zone 1 might be detected from packer tests in all zones in AW-2. If future cross-hole testing is performed in these wells, the test intervals and monitoring intervals should be set up so that a more unique interpretation of potential zones of communication can be made (see enclosed MDE Figure #2).

23) The last paragraph of page 41 states that "no other response was recorded in any of the other cross-hole tests and no ambient fluctuations in water levels were noted (except for the monitoring of AW-1, zone 1 during packer testing of AW-2, zones 3 and 4)".

MDE's review of the cross-hole test graphs in appendix H indicates that the following test curves support either possible or probable communication between wells:

A. AW-1, zone 1 (observation) during packer testing of AW-2, zone 1 and 2.

B. AW-1, zone 2 (observation) during packer testing of AW-2, zone 1 and 2.

C. AW-1, zone 1 (observation) during packer testing of AW-2, zone 3 and 4 (as mentioned in the draft FRI report).

Ambient fluctuations in aquifer water levels were much more pronounced in AW-1, zone 1 during packer testing of AW-2, zone 1 and 2 than in any other test.

Please review the text on page 41, paragraph 5 which relates to this comment and change or clarify the disputed portion.

24) Please number the packer test and cross-hole monitoring graphs in Appendix H so they can be referenced in a less cumbersome way.

Section 4.1.1 - Documented DNAPL

25) The last paragraph contains an erroneous conclusion concerning the success of DNAPL detection during the 1991-1994 site

investigation activities. In fact, 75% of the bedrock wells drilled contained visually observed DNAPL (3 out of 4 wells). 100% of the deep bedrock wells contained mobile DNAPL (AW-1 and AW-2). The only bedrock well in which DNAPL was not directly observed (VW-1) was drilled next to a soil boring in which DNAPL was observed in the shallow sand/rubble zone perched on top of the silty layer.

A pronounced low-velocity bedrock depression (fracture zone?) in the northwest part of the site between MW-1 and VW-1 is indicated by seismic refraction surveys (lines 1 and 3); auger refusal depths in borings (VW-1, B-1, B-2); geoprobe penetration depths (G-29); and bedrock seismic velocity trends (Figure 2-4). This is the same area where the evaporation lagoon and sludge disposal pits were formerly located. There is a possibility of DNAPL pooling and/or residual soil bound DNAPL concentrations throughout this area. Additional subsurface investigation, characterization, and sampling may be needed in this area.

One of the primary considerations throughout the FRI has been to limit invasive techniques that could spread DNAPL contamination to deeper subsurface horizons. As a result comparatively few bedrock wells were drilled. Because the site-specific DNAPL's are heavier than water and generally have very low viscosities, they quickly migrate through porous and fractured media, often leaving residual DNAPL in the pore systems that they pass through. Most of the 124 potential samples referred to in the FRI report that could have potentially contained mobile DNAPL compounds were in the unconsolidated porous media. Since there are no continuous, highly impermeable strata to prevent vertical migration of DNAPL's in the unconsolidated stratified media at this site, it would not be expected that mobile DNAPL compounds would be found there. The occurrence of residual DNAPL in the vicinity of spill and waste disposal areas and entrapped within fine-grained strata are the only type of direct DNAPL observations that would be reasonably expected in the unconsolidated strata. In the bedrock horizon beneath the unconsolidated strata, however, it is more likely that both residual and mobile DNAPL would be encountered. This was the case at this site.

The conclusion that it isn't feasible to accurately delineate the physical extent of DNAPL in the subsurface at this site is based primarily on the basis (for protective reasons) of sampling almost exclusively in subsurface media which would not be expected to contain mobile DNAPL. The few samples from subsurface media reasonably expected to contain mobile DNAPL had a 75% positive detection rate for mobile DNAPL.

Section 4.1.2 - Inferred DNAPL

26) The fourth paragraph on page 51 states that VW-3 is located in the center of the bedrock low situated in the southern part of the site. Figure 2-2, however, shows the location of VW-3 to be far removed from the center of this bedrock low.

Figure 2-2 is entitled "Bedrock Surface Topographic Map" but the data used to generate this map appear to be based primarily on the seismic refraction surveys. The accuracy of the seismic refraction method for determining subsurface depth to shallow refracting horizons is +-10-15% at best. The title of Figure 2-2 should be changed to "Seismic Depth To Bedrock Map" or some similar title that identifies the primary data source for this map are the seismic refraction surveys.

Borings B-11, B-12, B-13, MW-5, and VW-3 all suggest shallower bedrock elevations than are shown on Figure 2-2 for this portion of the bedrock aquifer. Bedrock seismic velocities, as indicated by refraction lines 5, 6 and 7, are more characteristic of the poorly-fractured, topographically positive bedrock terrain in the central and southwest portions of the site. Seismic lines 15 and 16, which are located closer to the creekbed, are more characteristic of the highly-fractured, deeply-weathered, topographically negative portions of the site where all of the observed mobile DNAPL occurrences are located.

27) The conclusion that DNAPL, if present, is likely to be present only in residual form within the overburden cannot be accepted based upon observations at the site. Mobile DNAPL was found perched on the clay/silt horizon in the middle of the unconsolidated overburden aquifer in boring B-1 and is likely to be present based on partitioning analyses in B-5, B-6, and B-7 (Figure 4-1). At boring B-4, a perched water zone is present above the clay/silt horizon. The split spoon sample taken through this perched water zone contained black viscous fluid with extremely strong smell of VOC's. The OVA meter experienced flameout (greater than 1000 ppm total organic vapor concentration) while monitoring the split spoon sample from this interval. The total VOC content for the sample analyzed from this interval by the field gas chromatograph was only 34.4 ppm. (Table 4-4). There are serious doubts about the validity of this analysis and the conclusion that no mobile DNAPLs are present in boring B-4.

The presence of mobile DNAPL above the silty clay layer (confirmed in B-1, strongly suggested in B-4 and possibly other borings) confirms that mobile DNAPL is currently in gravitationally unstable locations and will continue to migrate laterally to the stream or vertically into the fractured bedrock. Therefore, a continued threat to groundwater and surface water from known and inferred shallow mobile DNAPL's does exist beneath the site and should be addressed by appropriate remedial action.

The observed occurrence of mobile DNAPL in 3 out of 4 shallow bedrock wells, in conjunction with observations in the shallow unconsolidated aquifer, strongly suggest that mobile DNAPL is present in the shallow and deep aquifers beneath the site. These observations also are consistent with the continuing migration of mobile DNAPL from the shallow unconsolidated aquifer to deeper parts of the fractured bedrock.

Gneiss bedrock, such as that present beneath the site, weathers to a course-grained, sandy saprolite. Therefore, the weathered bedrock zone between the unconsolidated aquifer and the unweathered bedrock aquifer should not be a barrier to hydraulic communication. No significant continuous confining layer is present beneath the site to impede the vertical migration of DNAPL from the unconsolidated alluvial deposits into the fractured bedrock below. The silt/clay layer, where it is present, does appear to be a barrier to vertical DNAPL migration. As mentioned in the report, localized depressions within the upper surface of the silt/clay layer may contain pools of mobile DNAPL.

Section 4.2.2 - Overburden Ground Water Quality

28) Please compare the results for those samples which were analyzed both in the laboratory and with the field gas chromatograph. There are some very significant differences in concentrations detected by the two methods in some of the analyses shown in Tables 4-3, 4-4, 4-5, and 4-6. Please mention these differences and comment on their impact on the data interpretation and reliability.

Figure 2.7

29) Please correct the Caliper scale for well VW-1, and check the accuracy of the caliper scale on VW-2.

Section 5.1 - Conceptual Model of DNAPL Migration

30) Please define the specific subsurface conditions which allow mobile DNAPL compounds to be present in certain portions of the site (300 foot stretch of Little Elk Creek) and not in others. Please be specific about the particular subsurface aspects of the site which impact DNAPL migration and accumulation. It is appropriate that these site-specific subsurface parameters be defined here and their variability and spatial distribution determined from the investigation-derived data. These are necessary to compile the "conceptual model" mentioned in the first paragraph of this section.

31) Please reference specific aerial photos mentioned in the third paragraph of Section 5.1 and include "good photocopies" of these aerial photos in the report.

32) Please refer to MDE comment #10 in reference to the competent bedrock ridge mentioned in the fourth paragraph of Section 5.1.

33) The fourth paragraph of Section 5.1 states that well B-5 was "installed specifically to evaluate potential DNAPL migration along this pathway (but) did not encounter DNAPL." Figure 1-9 shows that Boring B-5 was converted to a DNAPL collection well. I was not able to find a well log or reference in the Step II Data Package (page 12) which gave the screened interval and sump location for the B-5 DNAPL collection well. Please include this

information on the Boring Log for B-5 in Appendix C. All of the B-series borings and DNAPL collection wells should also have OVA air monitoring results, field G.C. sample results, and off-site laboratory results specifically labeled on the boring logs so that contaminant distribution results can be more readily assessed.

The field G.C. results for the 9'-11' soil sample in boring B-5 were 171.5 ppm total V.O.C. It should be noted that this sample was taken in the fill above the actual top of the silt layer on which mobile DNAPL's were observed in boring B-1. Field G.C. sample results for soils within the zone of mobile DNAPL in B-1 were 204 ppm. The two results are close enough to be within the expected accuracy limit of the field G.C. at these very high contaminant concentrations, especially with the high levels of "unknown" VOC's present. These unknowns introduce a greater potential for inaccuracy because of the bias of the G.C. to detect the specific contaminants for which it has been calibrated. Based upon similar field analytical results for B-5 and B-1, sample interval in soil boring B-5, and screened interval in DNAPL collection well B-5(?), there is a strong possibility that mobile (or residual) DNAPL is present at this location on top of the silt layer and below the base of the well screen or sump.

34) Page 66, second paragraph. The discussion about fracturing in VW-2 being the pathway for DNAPL migration into the wellbore is not well substantiated by the borehole geophysical logs (Figure 2-7) or by the visual appearance of the core samples in terms of weathering characteristics associated with visible fracturing in the rock (see VW-2 core photos in Appendix C)

The caliper, resistance, and normal resistivity geophysical logs all indicate very tight, impermeable rock below the surface casing in VW-2. The caliper log shows very little deflection or rugosity of the borehole. Both the shallow (16" normal) and deep (64" normal) resistivity curves show extremely high resistivity, indicating that low permeability conditions persist away from the borehole as well as immediately adjacent to it.

In both VW-1 and VW-3, however, the caliper curve displays considerable spiking and the hole diameter is considerably larger, suggesting either softer rock or a high degree of fracturing (or both). This has allowed the hole to be physically enlarged during the coring procedure relative to the more dense, harder rock deeper in the borehole. The resistance and normal resistivity curves also record low formation resistivity values for some distance below the casing in VW-1 and VW-2. This response, in conjunction with the caliper and lower gamma-ray count, indicates fluid-filled, interconnected porosity in the rock. This porosity is probably a combination of enhanced fracturing and chemical weathering which has leached some of the more soluble components within the rock matrix. The rock forming minerals which are most susceptible to chemical weathering by groundwater are the same constituents which contribute most of the natural radiation recorded by the gamma ray log. These are the darker mafic and ultramafic minerals and the potassium feldspars.

35) Page 66, last paragraph. MDE believes that subsurface structure maps on top of the clay/silt layer and on the estimated top of bedrock (auger refusal depth) should be constructed from boring logs. These maps can show potential low areas where mobile DNAPL's may be pooled or where residual DNAPL's may be concentrated. When compared with the soil and groundwater analytical data, seismic data, and other subsurface data, a better pattern of DNAPL migration and distribution is likely to emerge. As previously mentioned in the FRI report, gravity is the single most important element controlling DNAPL migration. Since the bedrock surface and the silt/clay layer have been identified as the two most significant horizons on which DNAPL movement probably occurred, details of the subsurface elevation of these horizons (relative to a permanent datum such as mean sea level) is considered essential data to be included in the FRI Report.

36) Page 66, last sentence - continued on page 67. The statement that there was no direct observation of DNAPL in the overburden is misleading. Boring B-1 was reported in the FRI to contain 2 feet of mobile DNAPL on top of the silt/clay layer in the unconsolidated sediments. Although no mobile DNAPL was reported in boring B-5, total VOC levels recorded by the field G.C. were 171 ppm in B-5, compared to 204 ppm in the mobile DNAPL zone of boring B-1. These levels suggest that residual, if not mobile, DNAPL is present in B-5. Another very important aspect of the high soil VOC levels in boring B-5 is that it may be situated along a preferential migration pathway for mobile DNAPL's as they moved into the Creek DNAPL area. This possibility is further suggested by the extreme variation in elevations between the top of the silt/clay layer in MW-3 versus boring B-5, even though these two locations are less than ten feet from each other. This relationship can be seen in Figure 6 (Site Stratigraphy Fence Diagram) of the Step Two Data Package and Preliminary Interpretations Report dated October 15, 1993. This Figure clearly illustrates the potential mobile DNAPL pathway in boring B-5 and explains the high (residual DNAPL?) levels of VOC's found in soils above the silt/clay layer. Figure 2-1 in the Draft FRI report does not illustrate these relationships and should be replaced by Figure 6 of the Step Two Data Package.

<u>Figure 5-1</u>

37) There are a number of inaccuracies in this diagram. The diagram must be redone using accurate horizontal and vertical scales and employing investigation derived data points (monitoring wells, subsurface borings) and actual subsurface information from these data points.

Appendix A - Stream Orientation Study Results

38) An alternative (or additional) technique to quantify stream orientation data is suggested. The technique involves measuring the length of straight stream segments falling within specified azimuthal limits; summing the lengths of these segments within each azimuthal range; and displaying the results as a ratio or percentage of the total stream length under consideration. For example, the total length of Little Elk Creek between Route 273 and Childs Road (see street map in Appendix A) is approximately 16". The approximate total length of stream segments oriented within the North 45°-55° West (N 45°-55° W) azimuthal range is 5.9", or 38% of the total stream length of 16". Other significant azimuths for Little Elk Creek in the vicinity of the Spectron Site are N 35°-45° E and N 10°-0° W. It is believed that this technique will more accurately demonstrate and quantify the stream orientation trends in Little Elk Creek near the site.

Certain assumptions are made in applying this technique. First, there is expected to be minor azimuthal variation within what is termed a "straight segment" of the stream as the stream meanders within its relatively narrow drainage basin. As a result, the azimuth for any straight stream segment must be estimated from the best fitting azimuth along that segment of the stream. Another assumption is that straight stream segments which parallel the structural strike of dipping formations are controlled by formation boundaries rather than subsurface fracture zones. Stream orientation along these azimuths is more likely to be due to flow along more erosion-resistant formation boundaries than to flow controlled by subsurface fracture zones.

39) Appendix C - Please include the geologic logs for VW-1, VW-2 and VW-3 in Appendix C to compare with other wells and borings which only penetrated to auger refusal depth. Please include any air monitoring data which was recorded while drilling these wells.

40) Appendix H - Is there a graph of pressure vs. pumping rate for AW-2, zone 4? If so, please include in this appendix.

41) Appendix H - Refer to the graph for AW-1 Packer Testing of Interval #1, which is stated to be from 31.2' to 50.7'. Table 1-6, however, states that the packer test interval for this test is from 39.0' to 50.7'. Please reconcile this discrepancy.

42) Appendix H - last page in this Appendix. Well AW-2 does not have a zone 5. Is this calculation for K intended for well AW-1, zone 5?

43) Appendix L - Please summarize sample preparation and analysis procedures for on-site soil and water samples. Evaluate how the on-site analyses translate in terms of the actual

contaminant concentrations in the soil and groundwater in place at the sample location.

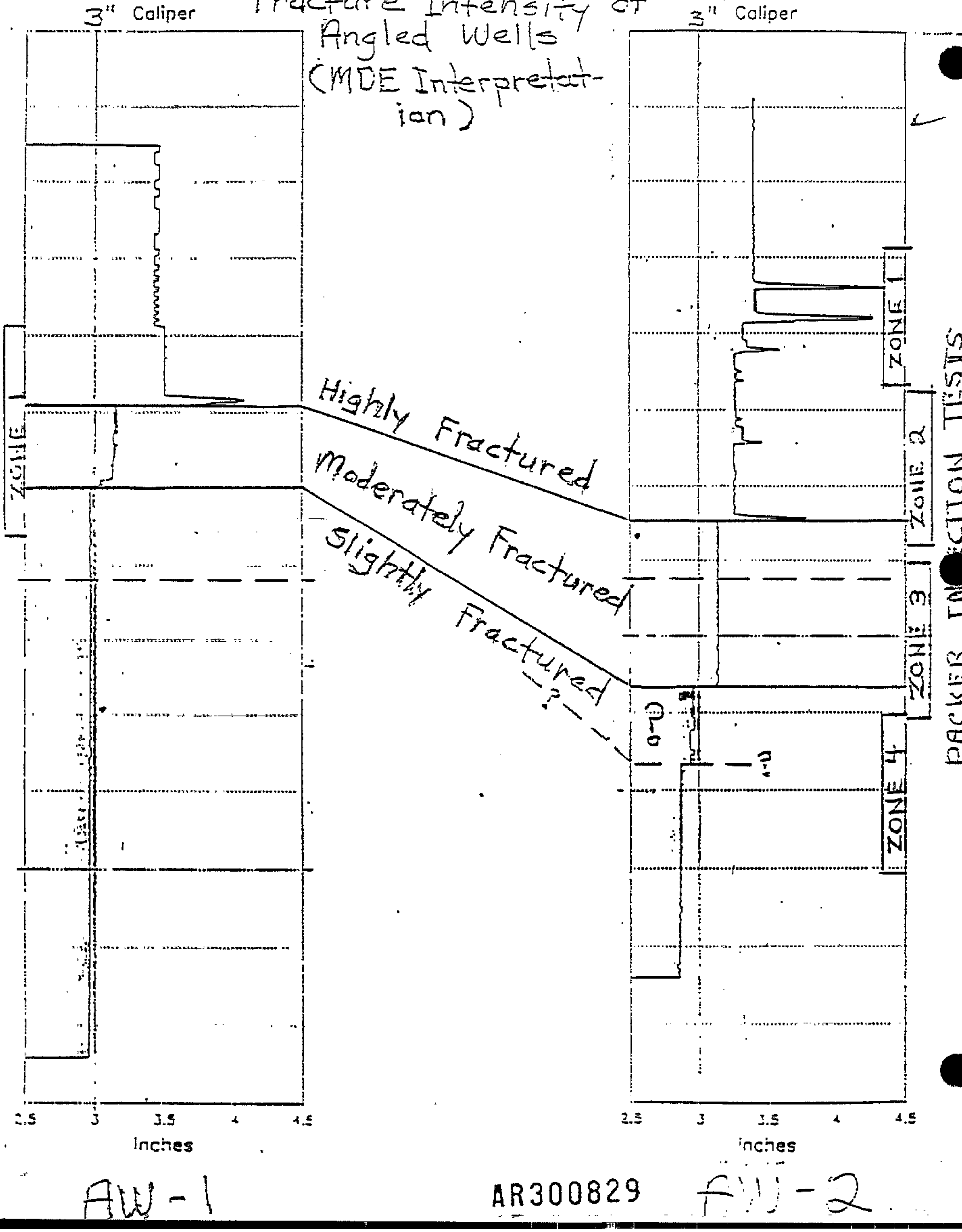
44) Appendix L - Piezometer, CLP Lab Data. Please provide sample identification summary sheets to identify the location and origin of each numbered sample. For example, the last two analyses in this section are designated as PZ-39 Grab Water Sample and FB-2 Field Blank Grab Water Sample. There is no PZ-39 piezometer. The location and origin of this sample cannot be determined from the available information.

Table 4-7

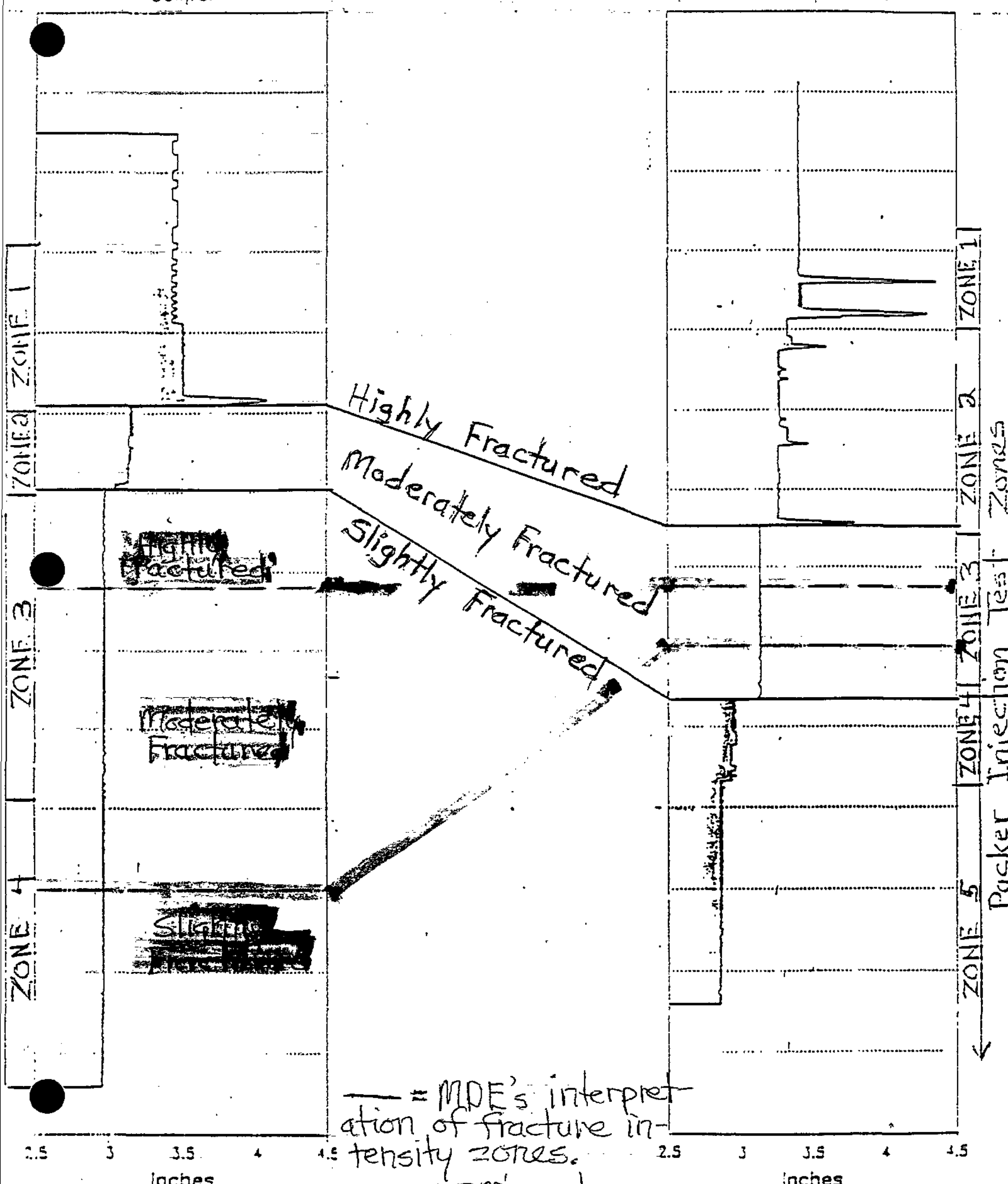
45) Groundwater concentrations of total volatile organic contaminants from packer tested intervals in the angled bedrock wells (Table 4-7) match very closely with the proposed fracture intensity zones in MDE comment #14 (See MDE Figure 1). When the total VOC concentrations in these wells are plotted on the caliper logs, there is a very good correlation of high VOC levels with these geophysically defined fracture intensity zones. The enclosed MDE Figure 3 illustrates these relationships. It was fortuitous that the sampled intervals correspond relatively well with the proposed fracture intensity zonations in these wells. A dramatic difference in groundwater contamination levels is present between the slightly fractured and the moderately fractured portions of each of these wells. Little or no significant difference in contamination levels is apparent, however, between the highly fractured and moderately fractured portions of these boreholes. The contaminant concentrations found within the slightly fractured bedrock intervals (up to 0.15% VOCs), confirms the likely presence of mobile DNAPL compounds in some fractures within these intervals. Because of decreased fracture intensity and decreased fracture aperture with depth, it is likely that most, if not all, mobile DNAPL is trapped in the marginally fractured parts of the bedrock in a dynamic equilibrium state. Although vertical migration deeper into the slightly fractured bedrock is unlikely, there is still the possibility of lateral migration into the moderately to highly fractured portions of bedrock fracture zones. MDE Figure 4 illustrates the potential for lateral DNAPL migration from the slightly fractured into the moderate to highly fractured portions of the bedrock aquifer.

Available site-specific subsurface data was compiled into a possible conceptual model to explain both the contaminant distribution and the petrophysical parameters of the bedrock aquifer. The enclosed MDE Figure 5 is included as a possible conceptual model for fracture relationships in the bedrock aquifer.

MDE Figure 1.
Fracture Intensity of Angled Wells (MDE Interpretation)



MDE Figure 2. Preferred Cross-~~Hole~~ Testing Program For Possible Future Tests.



—— = MDE's interpretation of fracture intensity zones.

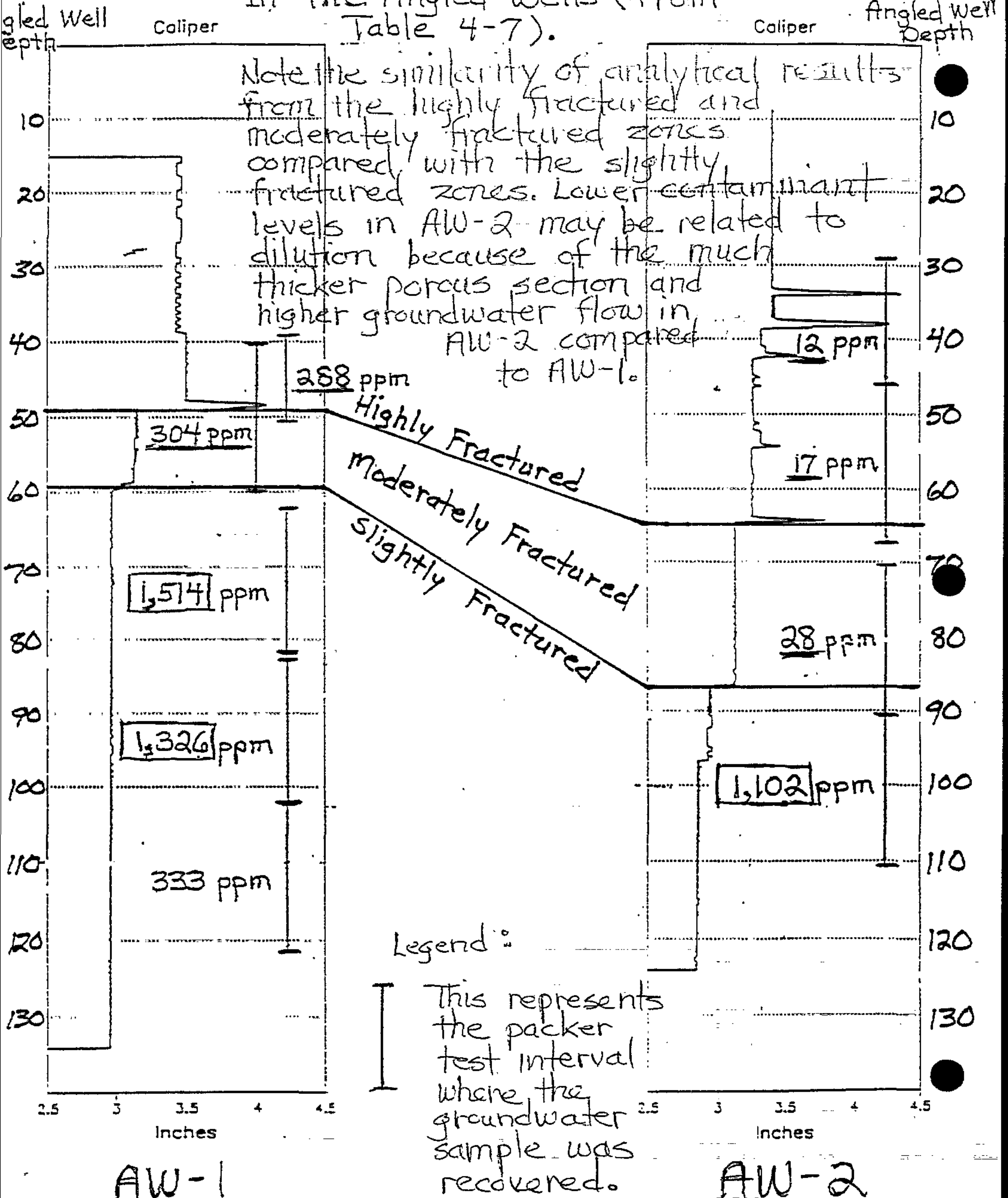
▬ = ERM's interpretation of fracture intensity zones

AW-1

AW-2

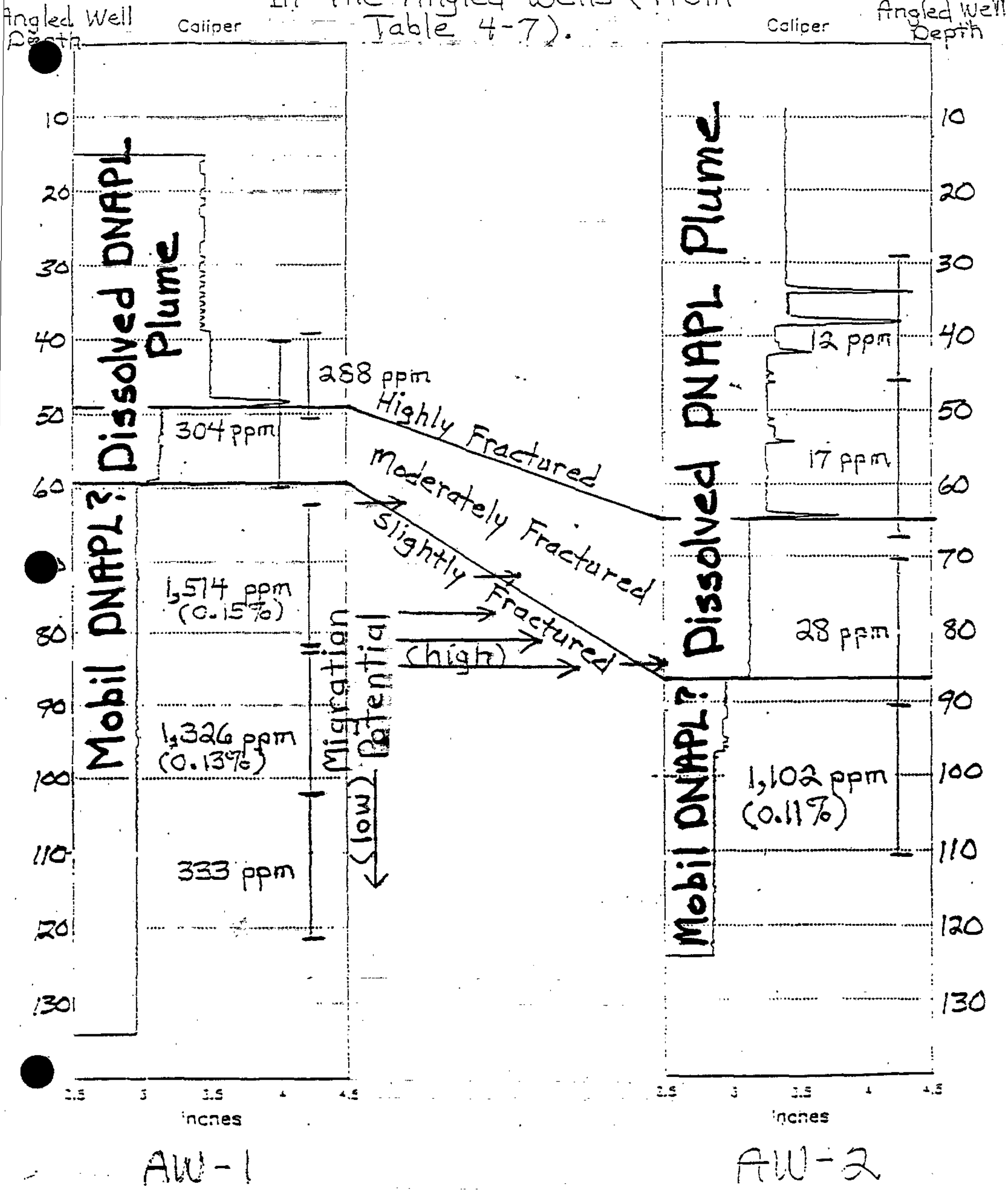
AR300830

MDE Figure 3. Ground Water Contamination Levels In The Angled Wells (From Table 4-7).

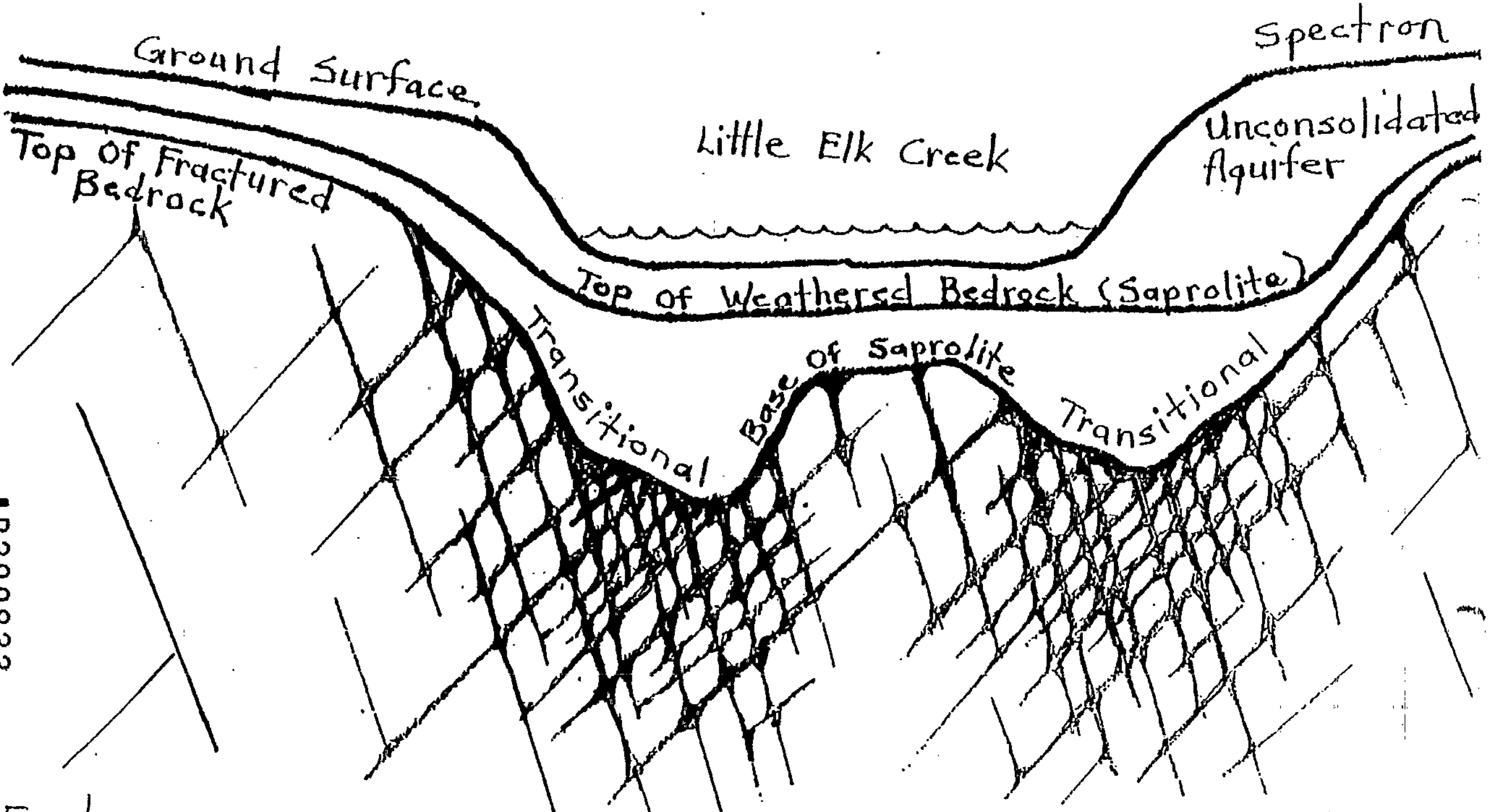


AR300831

MDE Figure 4! Ground Water Contamination Levels In The Angled Wells (From Table 4-7).



Title Figure 3. Conceptual Model Of Bedrock Fracture Zones, Spectron Site



Fracture Zones:
1) Increased fracture intensity
2) Better fracture communication
3) Increased weathering

Bedrock Fracture Zone (Preferred migration pathway)

Bedrock Fracture Zone (Preferred migration pathway)